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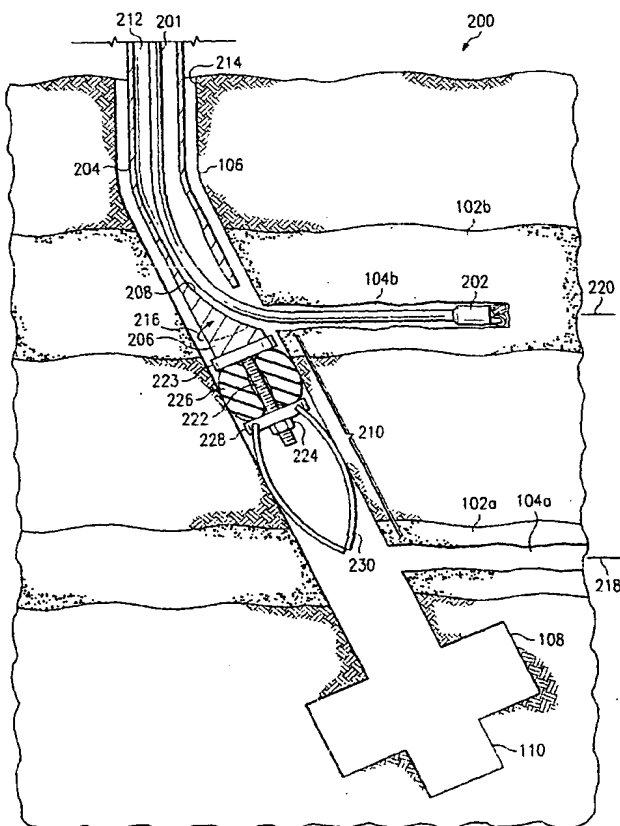
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[Continued on next page]

(54) Title: WELLBORE SEALING SYSTEM AND METHOD



(57) Abstract: In accordance with one embodiment of the present invention, a method for drilling wellbores includes drilling a main wellbore and disposing a casing string in the main wellbore. The casing string has a deflecting member and a sealing member coupled thereto. The method further includes disposing a drill string having a drill bit coupled at a lower end thereof in the casing string and drilling, from the main wellbore, a first lateral wellbore at a first depth with the drill bit. The method further includes removing the drill bit from the first lateral wellbore, transferring the casing string and the drill bit to a second depth that is higher than the first depth, drilling, from the main wellbore, a second lateral wellbore at the second depth with the drill bit, and preventing, using the sealing member, a fluid from the first lateral wellbore from flowing above approximately the second depth while drilling the second lateral wellbore.

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Declarations under Rule 4.17:

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WELLBORE SEALING SYSTEM AND METHOD

TECHNICAL FIELD OF THE INVENTION

The present invention relates generally to systems and methods for the recovery of subterranean resources and, more particularly, to a wellbore sealing system and method.

BACKGROUND OF THE INVENTION

Subterranean deposits of coal (typically referred to as "coal seams") often contain substantial quantities of entrained methane gas. Limited production and use of methane gas from coal seams has occurred for many years because substantial obstacles have frustrated extensive development and use of methane gas deposits in coal seams.

In recent years, various methods have been used to retrieve methane gas deposits from coal seams. One such method is the use of underbalanced drilling using a dual-string technique. As an example of this method, a fluid such as drilling fluid is circulated down a drill string, while another relatively light fluid such as air or nitrogen is circulated down an annulus formed between an outside surface of a drill string and an inside surface of a casing string. A mixture of these fluids is retrieved from an annulus formed between an outer surface of the casing string and an inside surface of the wellbore after mixing with a gas or other fluid obtained from a lateral wellbore being drilled. The purpose of the lighter fluid is to lighten the weight of the drilling fluid such that the hydrostatic head of the

drilling fluid does not force the drilling fluid into the subterranean formation and create detrimental effects.

SUMMARY OF THE INVENTION

5 The present invention provides a wellbore sealing system and method that substantially eliminates or reduces the disadvantages and problems associated with previous systems and methods.

10 In accordance with one embodiment of the present invention, a method for drilling wellbores includes drilling a main wellbore and disposing a casing string in the main wellbore. The casing string has a deflecting member and a sealing member coupled thereto. The method further includes disposing a drill string having a drill
15 bit coupled at a lower end thereof in the casing string and drilling, from the main wellbore, a first lateral wellbore at a first depth with the drill bit. The method further includes removing the drill bit from the first lateral wellbore, transferring the casing string and the
20 drill bit to a second depth that is higher than the first depth, drilling, from the main wellbore, a second lateral wellbore at the second depth with the drill bit, and preventing, using the sealing member, a fluid from the first lateral wellbore from flowing above approximately
25 the second depth while drilling the second lateral wellbore.

30 According to another embodiment of the present invention, a system for drilling wellbores includes a casing string, a deflecting member coupled to the casing string, and a sealing member coupled to the deflecting member. The sealing member is adapted to seal a wellbore into which the casing string is inserted such that a

fluid existing in the wellbore below the sealing member is prevented from flowing upward past the sealing member.

Some embodiments of the present invention may provide one or more technical advantages. These technical advantages may include more efficient drilling and production of methane gas and greater reduction in costs and problems associated with other drilling systems and methods. For example, there may be less damage to lateral wellbores because of mud or other fluids entering a lateral wellbore from the drilling of another lateral wellbore. In addition, cuttings are prevented from dropping into lower lateral wellbores while an upper lateral wellbore is being drilled. Another technical advantage includes providing a method for killing a lateral wellbore, while still being able to drill another lateral wellbore. An additional technical advantage is that underbalanced drilling may be performed along with the teachings of one embodiment of the present invention.

Other technical advantages of the present invention are readily apparent to one skilled in the art from the figures, descriptions, and claims included herein.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention and its advantages, reference is now made to the following description taken in conjunction with the accompanying drawings, wherein like numerals represent like parts, in which:

FIGURE 1 is a cross-sectional view illustrating an example slant well system for production of resources

from one or more subterranean zones via one or more lateral wellbores;

FIGURE 2 illustrates an example system for drilling lateral wellbores according to one embodiment of the present invention;

FIGURE 3 illustrates an example system for drilling lateral wellbores according to another embodiment of the present invention; and

FIGURE 4 is a flowchart demonstrating an example method for drilling lateral wellbores according to one embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Embodiments of the present invention and their advantages are best understood by referring now to FIGURES 1 through 4 of the drawings, in which like numerals refer to like parts.

FIGURE 1 is a cross-sectional view illustrating an example well system 100 for production of resources from one or more subterranean zones 102 via one or more lateral wellbores 104. In various embodiments described herein, subterranean zone 102 is a coal seam; however, other subterranean formations may be similarly accessed using well system 100 of the present invention to remove and/or produce water, gas, or other fluids. System 100 may also be used for other suitable operations, such as to treat minerals in subterranean zone 102 prior to mining operations, or to inject or introduce fluids, gasses, or other substances into subterranean zone 102.

Referring to FIGURE 1, well system 100 includes an entry wellbore 105, two main wellbores 106, a plurality of lateral wellbores 104, a cavity 108 associated with

each main wellbore 106, and a rat hole 110 associated with each main wellbore 106. Entry wellbore 105 extends from a surface 12 towards subterranean zones 102. Entry wellbore 105 is illustrated in FIGURE 1 as being substantially vertical; however, entry wellbore 105 may be formed at any suitable angle relative to surface 12 to accommodate, for example, surface 12 geometries and/or subterranean zone 102 geometries.

Main wellbores 106 extend from the terminus of entry wellbore 105 toward subterranean zones 102, although main wellbores may alternatively extend from any other suitable portion of entry wellbore 105. Where there are multiple subterranean zones 102 at varying depths, as illustrated in FIGURE 1, main wellbores 106 extend through the subterranean zones 102 closest to surface 12 into and through the deepest subterranean zones 102. There may be one or any number of main wellbores 106. As illustrated, main wellbores 106 are slant wells and, as such, are formed to angle away from entry wellbore 105 at an angle designated α , which may be any suitable angle to accommodate surface topologies and other factors similar to those affecting entry wellbore 105. Main wellbores 106 are formed in relation to each other at an angular separation of β degrees, which may be any suitable angle, such as 60 degrees. However, main wellbores 106 may be separated by other angles depending likewise on the topology and geography of the area and location of a targeted subterranean zone 102. Main wellbores 106 may also include cavity 108 and/or rat hole 110 located at a terminus of each wellbore 106. Main wellbore 106 may

include one, both, or neither cavity 108 and rat hole 110.

Lateral wellbores 104 extend from each main wellbore 106 into an associated subterranean zone 102. Lateral wellbores 104 are shown in FIGURE 1 to be substantially horizontal; however, lateral wellbores 104 may be formed in other suitable directions off of main wellbores 106 and may have a curvature associated therewith. Any suitable systems and/or methods may be used to drill lateral wellbores 104; however, a particular system for drilling lateral wellbores 104 according to one embodiment of the present invention is described below in conjunction with FIGURES 2 through 4.

FIGURE 2 illustrates an example system 200 for drilling lateral wellbores 104 according to one embodiment of the present invention. As illustrated, system 200 includes a drill string 201 having a drill bit 202, a casing string 204, a deflecting member 206 having a deflecting surface 208 coupled to a lower end of casing string 204, and a sealing member 210 coupled to a lower end of deflecting member 206.

Drill string 201 may be any suitable drill string having any suitable length and diameter and any suitable drill bit 202 for the purpose of drilling lateral wellbores 104. Drill string 201 is typically a hollow conduit for allowing drilling fluids to flow therethrough. Drill bit 202 may be driven through the use of any suitable motor powered by the drilling fluid and may have any suitable configuration. To direct drill string 201 and drill bit 202 for the purpose of drilling lateral wellbore 104, deflecting surface 208 of deflecting member 206 is utilized.

Casing string 204 may be any suitable casing string having any suitable diameter that is to be inserted into main wellbore 106. Casing string 204 is adapted to rotate within main wellbore 106 as illustrated by arrow 216. An inner annulus 212 is formed between the inner surface of casing string 204 and the outer surface of drill string 201. An outer annulus 214 is also formed between an outside surface of casing string 204 and the surface of main wellbore 106. Inner annulus 212, outer annulus 214, and drill string 201 may be used to perform underbalanced drilling. As one example of underbalanced drilling, a first fluid may be circulated down drill string 201, such as drilling mud or other suitable drilling fluids. A second fluid is circulated down inner annulus 212, such as air, nitrogen, or other relatively light fluid. Both first and second fluids may be retrieved from outer annulus 214 after mixing with a gas or other fluid produced from lateral wellbore 104. The purpose of the second fluid is to lighten the weight of the first fluid such that the hydrostatic head of the first fluid does not force first fluid into the subterranean formation. As a variation, the second fluid may be circulated down outer annulus 214 and the mixture of the first and second fluids along with the gas from lateral wellbore 104 may be retrieved via inner annulus 212.

According to the teachings of the present invention, sealing member 210 is adapted to seal main wellbore 106 such that a fluid existing in main wellbore 106 below sealing member 210 is prevented from flowing upward past sealing member 210. In one embodiment of the invention, this allows the drilling of a lateral wellbore 104a in a

subterranean zone 102a at a first depth 218 and then the drilling of a lateral wellbore 104b in a subterranean zone 102b at a second depth 220, while ensuring that any gas or other fluid obtained from lateral wellbore 104a at first depth 218 does not flow past sealing member 210 and interfere with the drilling of lateral wellbore 104b in subterranean zone 102b at second depth 220. In addition, any cuttings resulting from the drilling of lateral wellbore 104b are prevented from dropping into lateral wellbore 104a. An example sealing member 210 is illustrated in FIGURE 2.

As illustrated in FIGURE 2, example sealing member 210 includes a bolt 222, a nut 224, a plug 226, a washer 228, and a resilient member 230. Bolt 222 is coupled to a lower end 223 of deflecting member 206 in any suitable manner. Nut 224 is threaded on bolt 222, while washer 228 surrounds bolt 222 and is rigidly coupled to nut 224. Plug 226 surrounds bolt 222 and is disposed between washer 228 and lower end 223 of deflecting member 206.

Plug 226 is formed from any suitable material, such as an elastomer, resilient enough to be circumferentially expanded or circumferentially retracted but stiff enough to be able to prevent any gas or other fluid existing in main wellbore 106 below sealing member 210 to leak past plug 226. The circumferential expansion or retraction of plug 226 via the rotation of casing string 204 is described in more detail below. In other embodiments, plug 226 is an air-filled diaphragm formed from any suitable material.

Resilient member 230 is coupled to washer 228 in any suitable manner. Resilient member 230, which may be any suitable resilient member, such as a bow spring, is

adapted to engage the wall of main wellbore 106 and apply enough force to the wall of main wellbore 106 to prevent nut 224 and washer 228 from turning while casing string 204 is rotated within main wellbore 106. Washer 228 and nut 224 are fixed to one another such that, when casing string 204 is rotated, nut 224 and washer 228 do not rotate. In this way, bolt 222 may longitudinally compress plug 226 to circumferentially expand plug 226 so that it may press against the wall of main wellbore 106 to prevent gas or other fluid from flowing upward past plug 226. Conversely, when casing string 204 is rotated in an opposite direction, then bolt 222 acts to longitudinally decompress plug 226, thereby circumferentially retracting plug 226 so that gas or other fluid may bypass plug 226.

In operation of one embodiment of system 200 of FIGURE 2, main wellbore 106 is drilled via any suitable method. Casing string 204 having deflecting member 206 and sealing member 210 attached thereto is inserted into main wellbore 106. While lowering casing string 204 down main wellbore 106, plug 226 is in a circumferentially retracted position so that any air or other fluid existing at a depth below sealing member 210 may leak past plug 226. Once at a desired depth, such as first depth 218, drill string 201 is inserted within casing string 204 so that lateral wellbore 104a may be drilled at first depth 218. After drilling lateral wellbore 104a drill string 201 is retracted from lateral wellbore 104a. At this time, casing string 204 is rotated in a desired direction so that plug 226 may be longitudinally compressed and circumferentially expanded to press against the wall of main wellbore 106. As described

above, this prevents any gas or other fluid produced from lateral wellbore 104a from traveling up past plug 226. Casing string 204 may then be raised to second depth 220 so that lateral wellbore 104b may be drilled. Lateral wellbore 104b may then be drilled with drill bit 202 with the assurance that sealing member 210 will prevent any gas or fluid from passing upward and causing detrimental effects. Other lateral wellbores 104 may be drilled successively at shallower depths according to a similar procedure. Many different types of sealing members 210 are contemplated by the present invention. Another example sealing member is shown below in conjunction with FIGURE 3.

FIGURE 3 illustrates another example sealing member 310. In one embodiment, sealing member 310 is a resilient plunger 300 formed from a suitable elastomer; however, other suitable resilient materials may be utilized. As illustrated, plunger 300 includes a plurality of ridges 302 that have an inherent stiffness to prevent gas or other fluid from a depth in main wellbore 106 below plunger 300 from leaking past plunger 300 to a higher depth (or vice versa) while a lateral wellbore 104 is being drilled. In addition, plunger 300, via ridges 302, possesses enough resiliency to allow gas or other fluid existing at a depth below plunger 300 to flow past plunger 300 to relieve any potential increasing pressure below plunger 300 when plunger 300 is inserted into main wellbore 106. Plunger 300 may have other suitable configurations and may be coupled to deflecting member 206 in any suitable manner. In other embodiments, plunger 300 is a hollow plunger having any suitable fluid therein.

Plunger 300 may also include a relief valve (not shown) that is operable to allow gas or other fluid at a depth below plunger 300 to flow to a depth above plunger 300 when a predetermined pressure is reached. Any
5 suitable relief valve may be utilized and the relief valve may be coupled to plunger 300 in any suitable manner. The relief valve may be set to open or close at a predetermined pressure depending on the pressure expected to be encountered in main wellbore 106 below
10 sealing member 310. A relief valve may also be utilized with sealing member 210 of FIGURE 2 in a similar manner.

FIGURE 4 is a flow chart demonstrating an example method of drilling lateral wellbores 104 according to one embodiment of the present invention. The method begins
15 at step 400 where main wellbore 106 is drilled. Casing string 204 having deflecting member 206 at a lower end thereof is disposed in main wellbore 106 at step 402. Deflecting member 206 has any suitable sealing member coupled at a lower end thereof. Although example sealing
20 members 210 and 310 are described above, any suitable sealing member may be used within the scope of the present invention.

As described above, the sealing member prevents a gas or other fluid from a lower lateral wellbore from
25 flowing up to a higher lateral wellbore at a higher depth while drill string 201 is drilling the higher lateral wellbore. At step 404, drill string 201 having drill bit 202 is disposed in casing string 204. At step 406, a first lateral wellbore 104a is drilled from main wellbore
30 106 at first depth 218. Deflecting surface 208 of deflecting member 206 is utilized to direct drill string 201 in the desired drilling direction.

After first lateral wellbore 104a is drilled, drill bit 202 is removed from first lateral wellbore 104a at step 408. At step 410, casing string 204 and drill bit 202 are transferred to second depth 220 that is less than first depth 218. Any gas or other fluid produced from first lateral wellbore 104a is prevented, as denoted by step 412, from flowing up to second depth 220 by the sealing member. At step 414, second lateral wellbore 104b is drilled from main wellbore 106 at second depth 220 with drill bit 202. Successive lateral wellbores 104 may be drilled at successively higher depths per the above method. In lieu of a slant well system, the described example method may be used with other suitable well systems.

Although the present invention is described with several embodiments, various changes and modifications may be suggested to one skilled in the art. The present invention intends to encompass such changes and modifications as they fall within the scope of the appended claims.

WHAT IS CLAIMED IS:

1. A method for drilling wellbores, comprising:

drilling a main wellbore;

disposing a casing string in the main wellbore, the casing string having a deflecting member and a sealing member coupled thereto;

disposing a drill string having a drill bit coupled at a lower end thereof in the casing string;

drilling, from the main wellbore, a first lateral wellbore at a first depth with the drill bit;

removing the drill bit from the first lateral wellbore;

transferring the casing string and the drill bit to a second depth that is higher than the first depth;

drilling, from the main wellbore, a second lateral wellbore at the second depth with the drill bit; and

preventing, using the sealing member, a fluid from the first lateral wellbore from flowing above approximately the second depth while drilling the second lateral wellbore.

2. The method of Claim 1, further comprising:

removing the drill bit from the second lateral wellbore;

transferring the casing string and the drill bit to a third depth that is higher than the second depth;

drilling, from the main wellbore, a third lateral wellbore at the third depth with the drill bit; and

preventing, using the sealing member, the gas from flowing above approximately the third depth while drilling the third lateral wellbore.

3. The method of Claim 1, wherein drilling the main wellbore comprises drilling a slant wellbore.

4. The method of Claim 1, further comprising disposing the casing string in the main wellbore such that an outer annulus is formed between a wall of the main wellbore and an outer wall of the casing string, and disposing the drill string in the casing string such that an inner annulus is formed between an inner wall of the casing string and an outer wall of the drill string.

5. The method of Claim 4, further comprising:
circulating a first fluid down an inner passage of the drill string;

circulating a second fluid down the inner annulus;
regulating an amount of the second fluid to prevent the first fluid from entering a subterranean formation in which the lateral wellbore is being drilled; and

retrieving a mixture of the first and second fluids and the gas from the lateral wellbore through the outer annulus.

6. The method of Claim 4, further comprising:
circulating a first fluid down an inner passage of the drill string;

circulating a second fluid down the outer annulus;
regulating an amount of the second fluid to prevent the first fluid from entering a subterranean formation in which the lateral wellbore is being drilled; and

retrieving a mixture of the first and second fluids and the gas from the lateral wellbore through the inner annulus.

7. The method of Claim 1, wherein disposing the casing string in the main wellbore comprises lowering the casing string down the main wellbore while allowing a fluid in the main wellbore below the sealing member to flow past the sealing member.

8. The method of Claim 1, wherein preventing the gas from the first lateral wellbore from flowing above approximately the second depth while drilling the second lateral wellbore comprises longitudinally compressing a plug of the sealing member to circumferentially expand the plug such that an outer surface of the plug engages a wall of the main wellbore.

9. The method of Claim 8, further comprising rotating the casing string to longitudinally compress the plug.

10. The method of Claim 1, wherein preventing the gas from the first lateral wellbore from flowing above approximately the second depth while drilling the second lateral wellbore comprises utilizing a resilient plunger as the sealing member.

11. A system for drilling wellbores, comprising:
a casing string;
a deflecting member coupled to the casing string;
and

5 a sealing member coupled to the deflecting member,
the sealing member configured to seal a wellbore into
which the casing string is inserted such that a fluid
existing in the wellbore below the sealing member is
prevented from flowing upward past the sealing member.

10 12. The system of Claim 11, wherein the sealing
member comprises a resilient plunger.

15 13. The system of Claim 12, wherein the sealing
member further comprises a relief valve operable to allow
a fluid in the wellbore below the resilient plunger to
flow past the resilient plunger.

20 14. The system of Claim 11, wherein the sealing
member comprises a solid plug.

15. The system of Claim 14, wherein the sealing
member further comprises:

25 a bolt to support the solid plug;
a nut coupled to the bolt;
a washer disposed between the nut and the plug; and
a spring member coupled to the washer, the spring
member adapted to engage a wall of the wellbore to
prevent the washer from rotating when the casing string
30 is rotated in the wellbore such that the solid plug is
longitudinally compressed and circumferentially expanded
to engage the wall of the wellbore.

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16. The system of Claim 11, wherein the sealing member comprises an air-filled diaphragm.

17. A sealing member, comprising:

a resilient plunger adapted to couple to an end of a casing string and operable to prevent a gas within a wellbore from flowing from a lower depth below the resilient plunger to a higher depth above the resilient plunger while a lateral wellbore is being drilled.

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18. A sealing member, comprising:

a bolt adapted to couple to an end of a casing string;

a nut rotatably coupled to the bolt;

5 a washer engaged with the nut;

a plug surrounding the bolt and resting against the washer;

10 a spring member coupled to the washer, the spring member adapted to engage a wall of a wellbore to prevent the washer from rotating when the casing string is rotated in the wellbore such that the plug is longitudinally compressed and circumferentially expanded to engage the wall of the wellbore to prevent a gas within the wellbore from flowing from a lower depth below the plug to a higher depth above the plug while a lateral wellbore is being drilled.

15 19. The sealing member of Claim 18, wherein the spring member is adapted to engage the wall of the wellbore to prevent the washer from rotating when the casing string is rotated in the wellbore such that the plug is longitudinally expanded and circumferentially retracted to allow a gas within the wellbore from flowing from a lower depth below the plug to a higher depth above the plug.

20 20. The sealing member of Claim 18, wherein the plug comprises an air-filled diaphragm.

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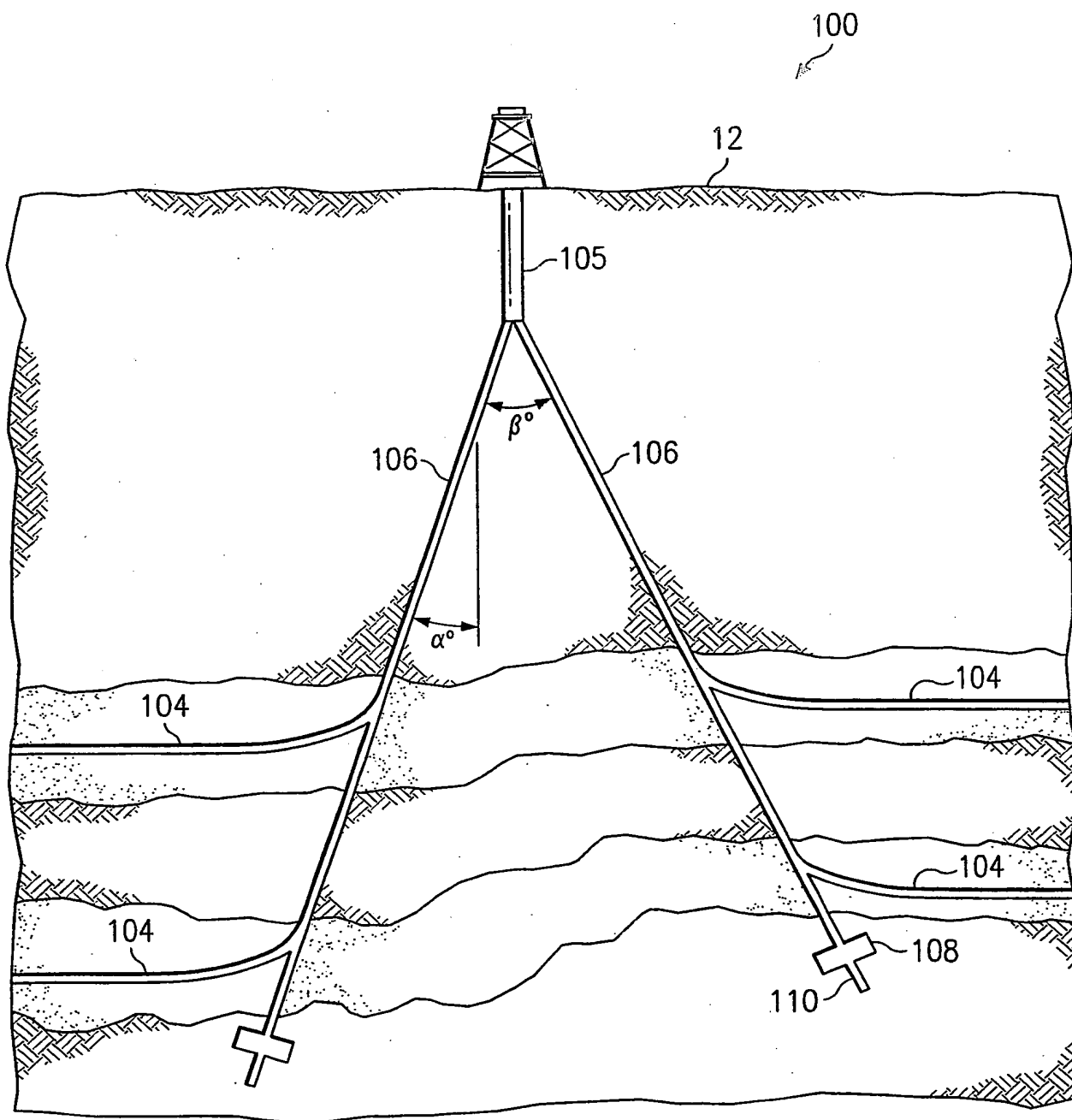


FIG. 1

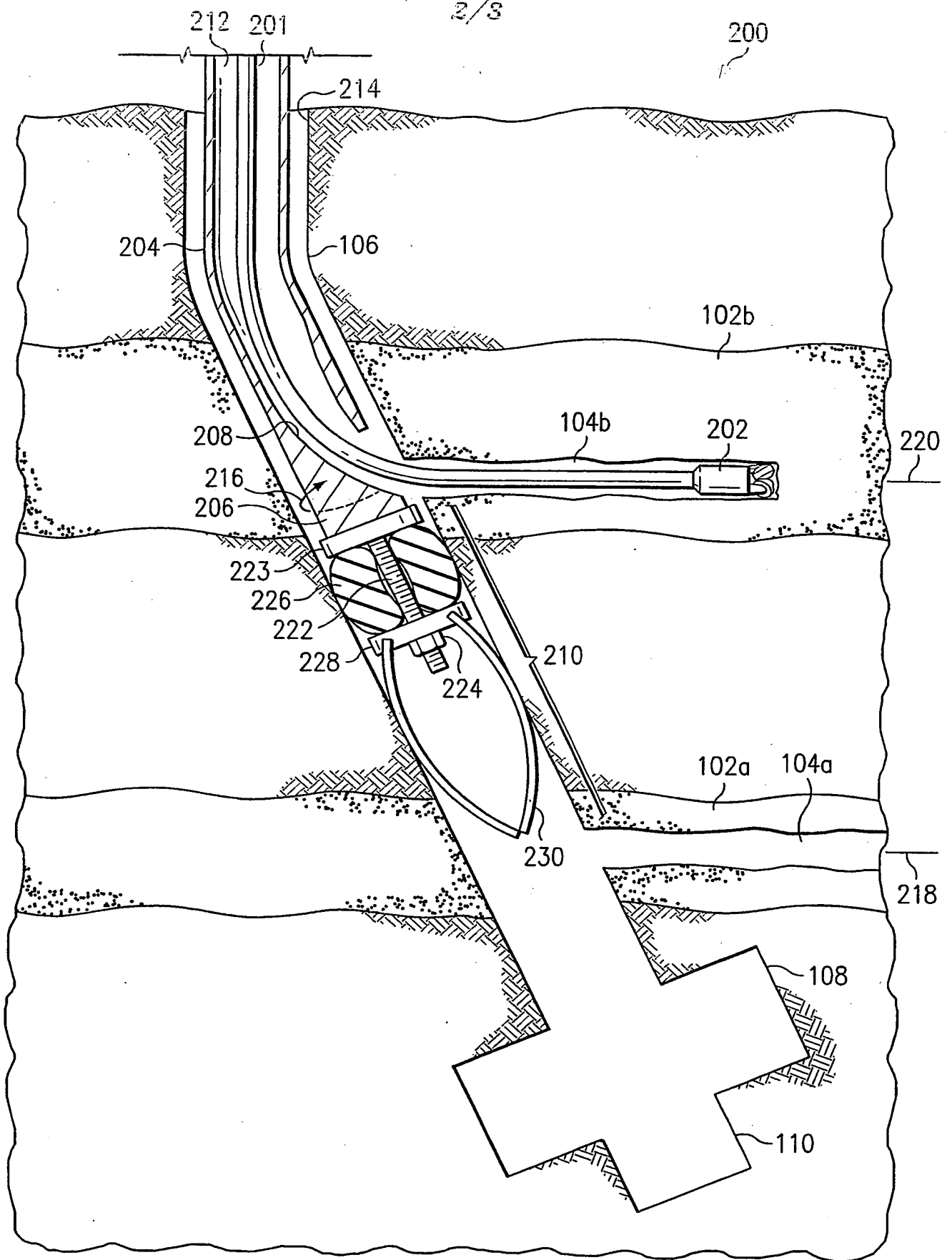


FIG. 2

FIG. 4

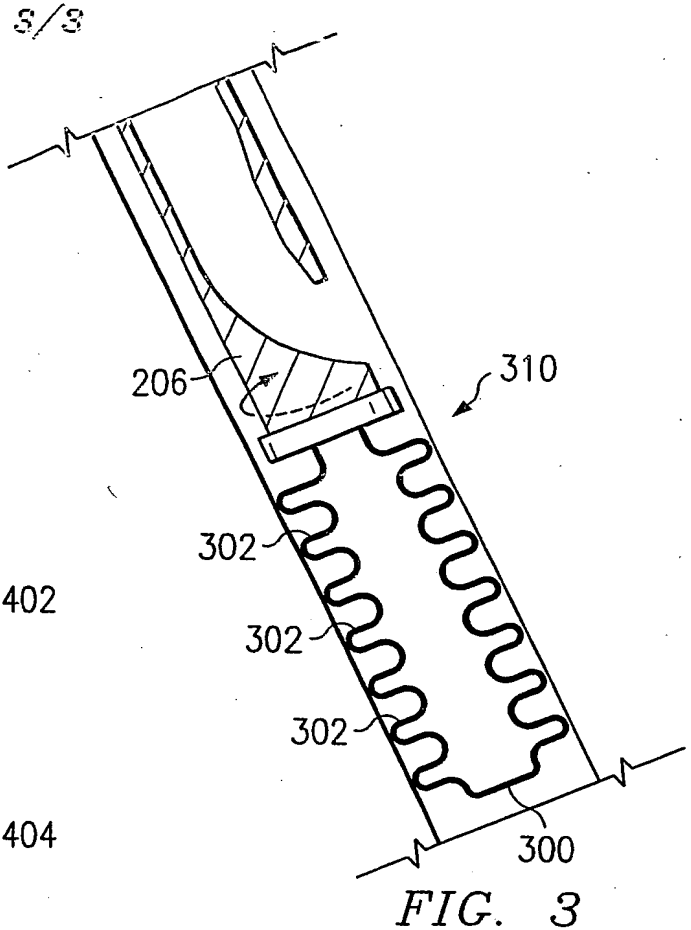
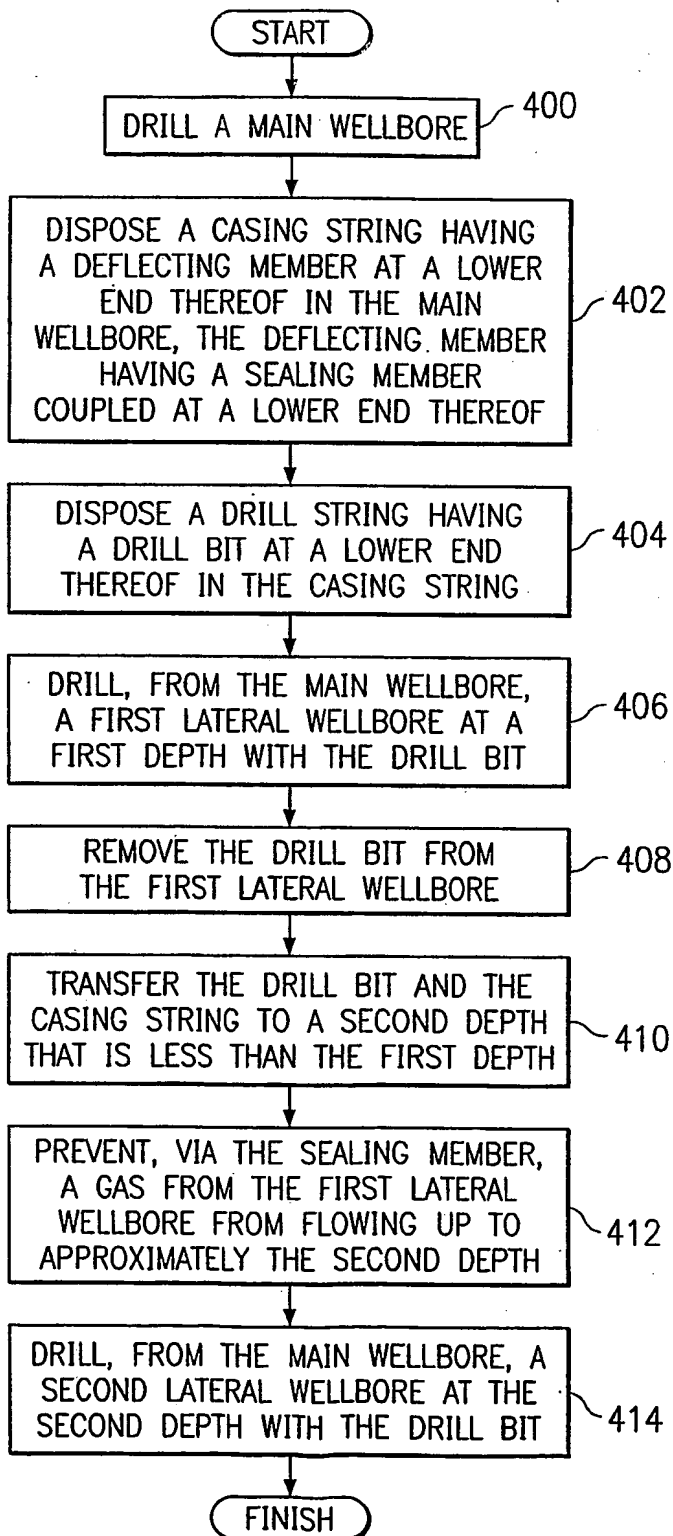


FIG. 3

INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US 03/21628

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 E21B7/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

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04/11/2003

Name and mailing address of the ISA

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INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US 03/21628

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